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UERRA General Assembly and Review Meeting
1-3 February, Météo-France, Toulouse

A cloud reanalysis using a NWP model together with data from polar-orbiting and geostationary satellites

Tomas Landelius and Jelena Bojarova

Swedish Meteorological and Hydrological Institute

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European cloud cover reanalysis using best available data at any given time, 1982 - 2013

Horizontal resolution:

– 5.5 km MESAN EURO4M

Time resolution:

– Hourly for the period 1982– 2013.

Observations:

– CMSAF polar orbit AVHRR cloud mask 1982 – 2009.

– CMSAF geostationary SEVIRI cloud mask 2004 – 2012.

– CMSAF new polar orbit & geostationary CM SAF cloud cover probability product for MFG (1983-2005) and MSG (2004-2013)

(ready early 2016, MeteoSwiss)

First guess:

– EURO4M 22 km HIRLAM 3DVar, 1982 – 2013.

– HIRLAM EURO4M 22 km interpolated to 5.5 km using LSM

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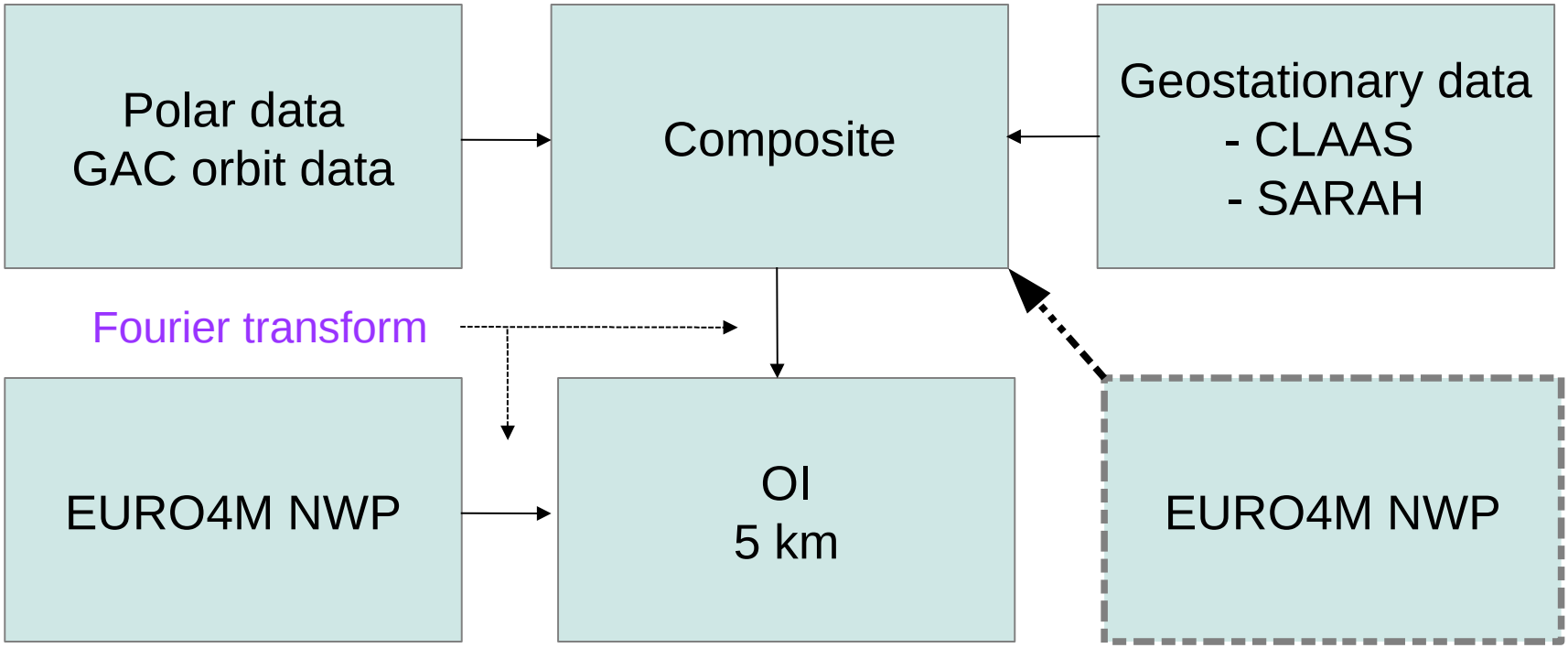
Processing chain



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Data resolution

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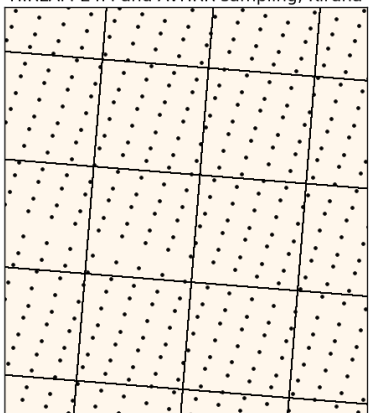
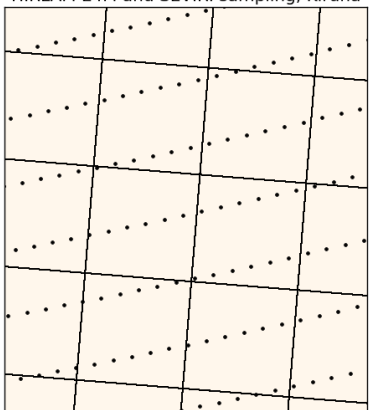
North

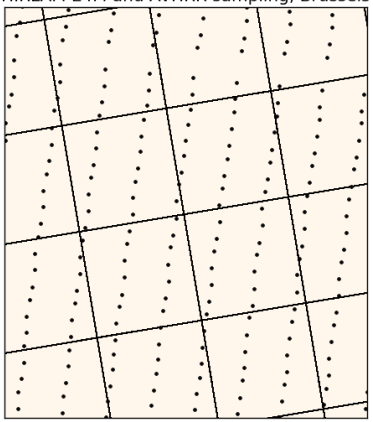
HIRLAM E4M and AVHRR sampling, Kiruna



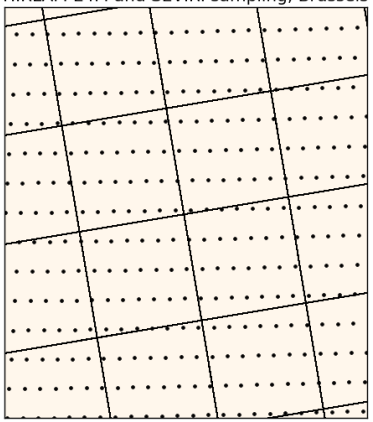
HIRLAM E4M and SEVIRI sampling, Kiruna

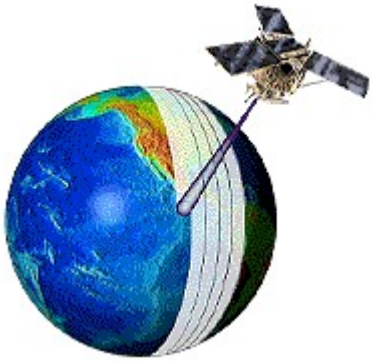


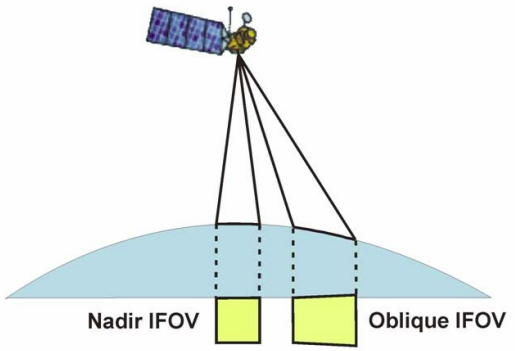
HIRLAM E4M and AVHRR sampling, Brussels



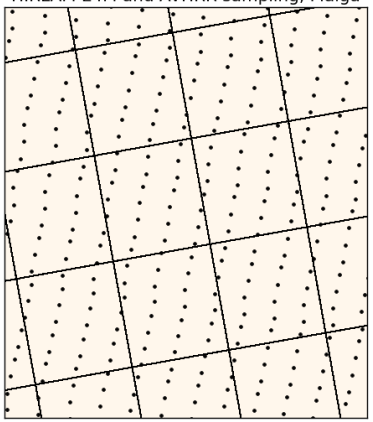
HIRLAM E4M and SEVIRI sampling, Brussels



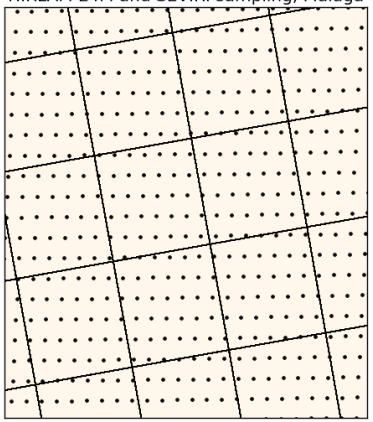




HIRLAM E4M and AVHRR sampling, Malga



HIRLAM E4M and SEVIRI sampling, Malaga



South

"Pilot" study :
OI scheme on
22km resolution

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Super observations for 20060622:10 UTC

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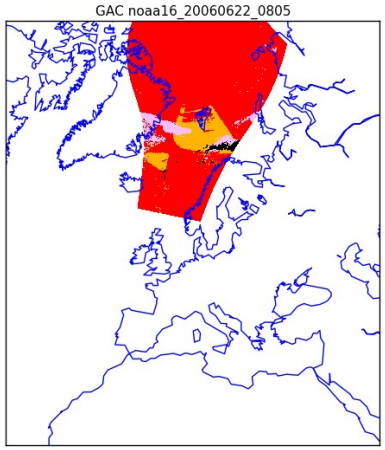
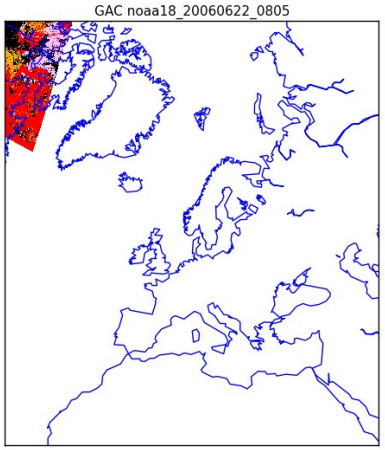
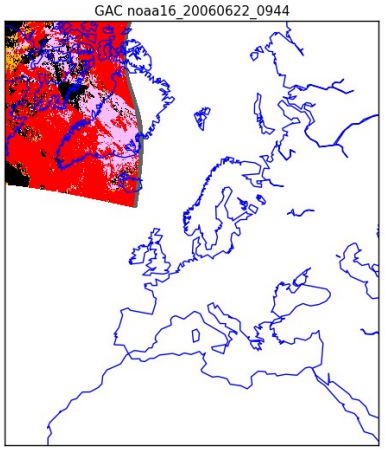
NOAA16 08:05 | NOAA18 08:05 | NOAA16 09:44

Polar GAC

$T-\Delta T \leq T_k \leq T+\Delta T$

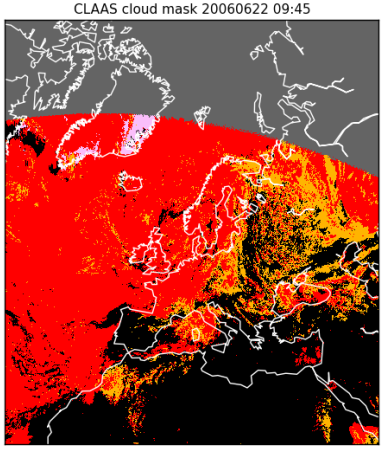


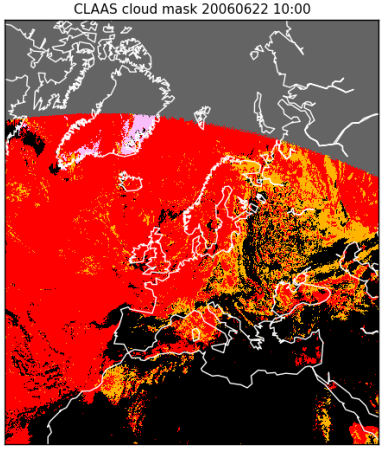


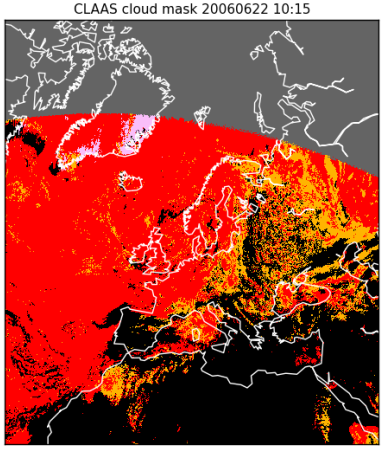


Polar CLASS

T_{k-1}, T_k, T_{k+1}







09:45 | 10:00 | 10:15

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Super observations, continued 1...

Use the quality and scan geometry information available in CMSAF products to calculate weights:

$$w = f\left(quality\ flags, sat\ angles, time\ delta\right)$$

Calculate cloud fractional cover as a weighted fraction of cloudy pixels within a HIRLAM grid box:

$$CFC = \frac{\sum w_i\ CM_i}{\sum w_i}$$

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Super observations, continued 2...

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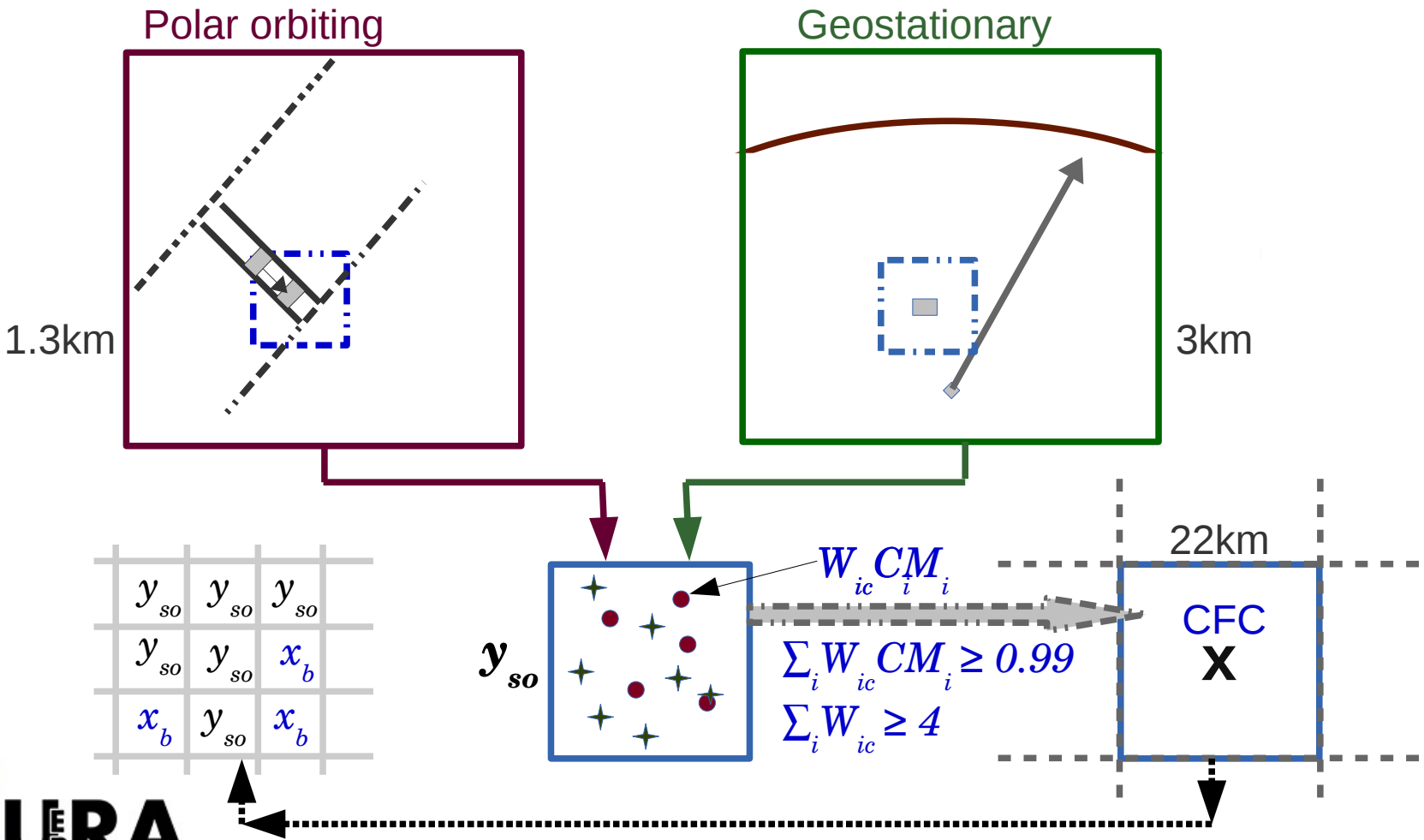
W_{ic} (*timeliness, view angle, cumulative quality flag*)



HIRLAM EURO4M Cloud Fraction is used as “gap-filler” in grids where no CM observations available

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Mesan: Optimal Interpolation

$$x_a = x_b + K\left(y - H\left(x_b\right)\right)$$
$$K = BH^T\left(HBH^T + R\right)^{-1}$$

B matrix

– Diagonal in Fourier space, i.e. homogeneous
– HIRLAM NMC statistics (fc differences) as the “first-guess” for σ_B and L_B

R matrix (spatially correlated errors)

– Diagonal in Fourier space, i.e. homogeneous
– The “first-guess” : $\sigma_R = 0.1 * \sigma_B$ and $L_R = 0.5\, L_B$

Re-estimate statistics based on Desroziers diagnostics from the “pilot” run

H operator : identity matrix

– extract Cloud Fraction from HIRLAM EURO4M forecasts

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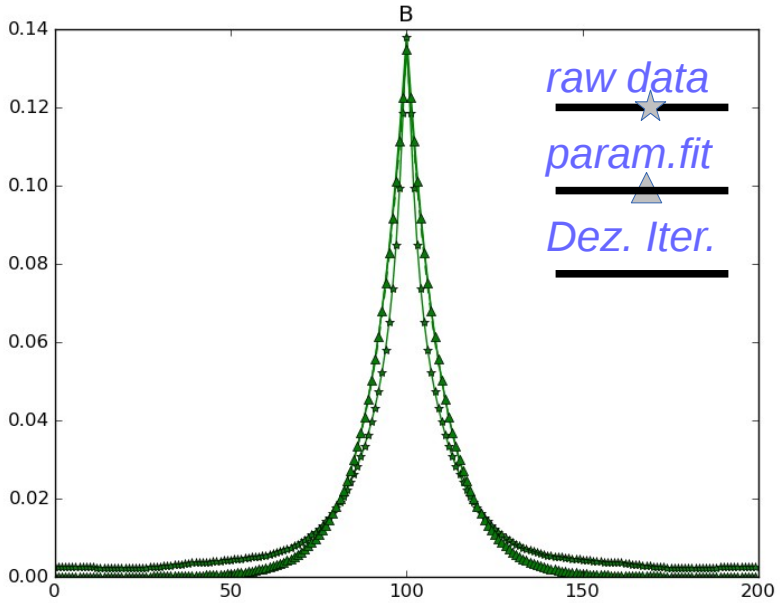
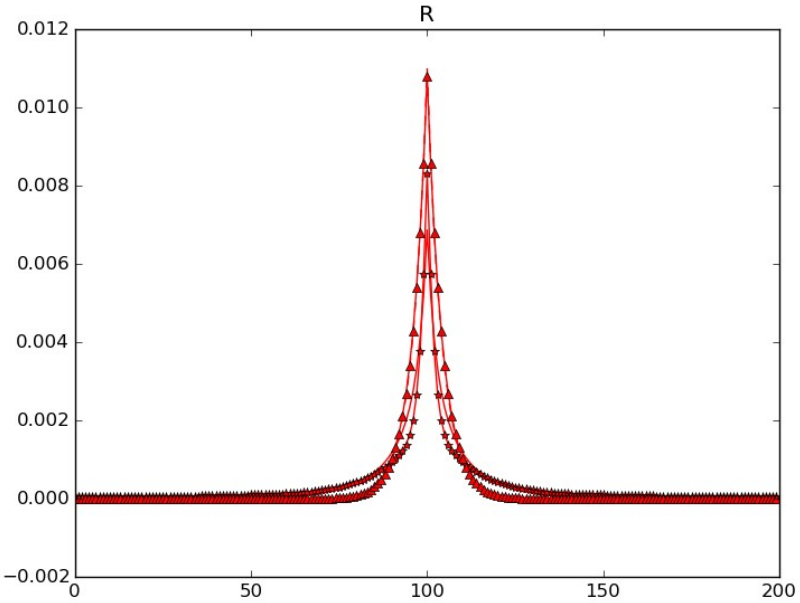
Desroziers diagnostic of B and R statistics

B



R



First iteration based on Desroziers diagnostics

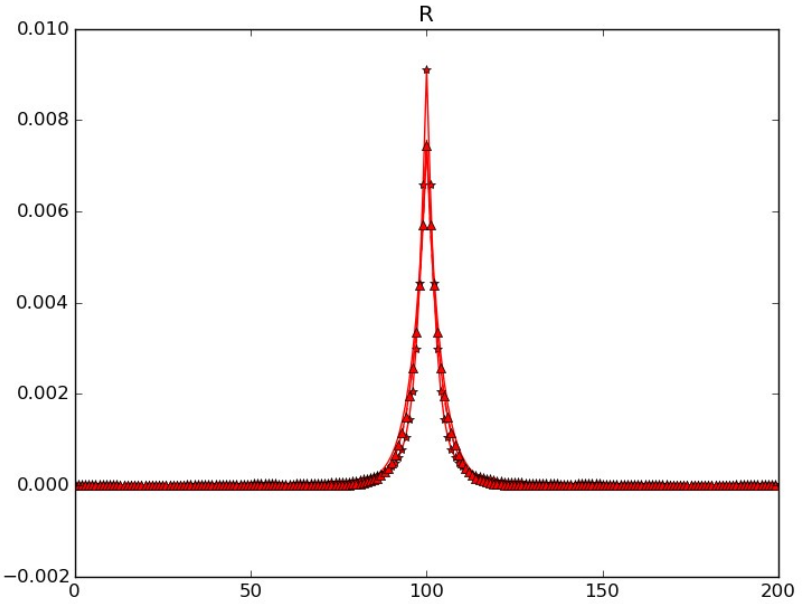
$\mathrm{cov}(x,y) = \sigma \exp(-L|x-y|)$

$$d^y_b = y - H(x_b);\ d^y_a = y - H(x_a)$$

$$D = E(d^y_b{}^T d^y_b) = (H^T B H + R)$$

$$R^* = E(d^y_a{}^T d^y_b) =$$

$$R^o (H^T B^o H + R^o)^{-1} (H^T B H + R)$$



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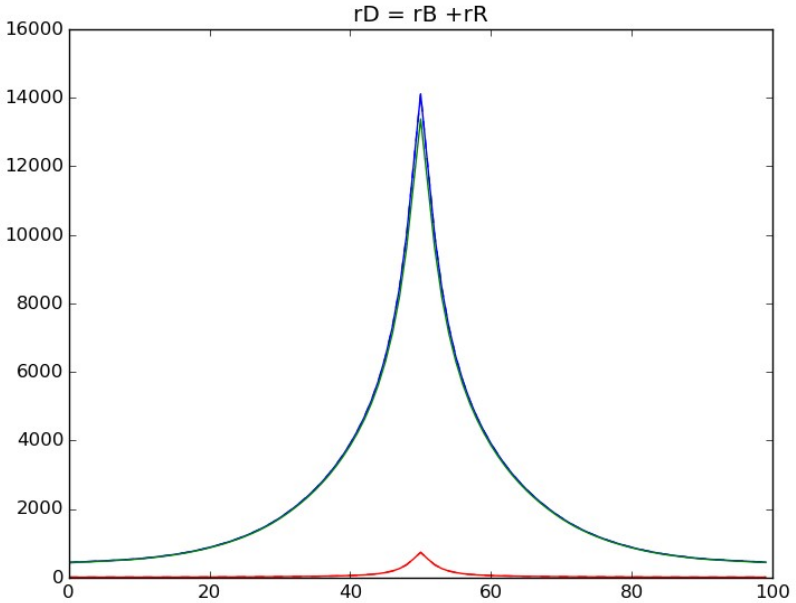
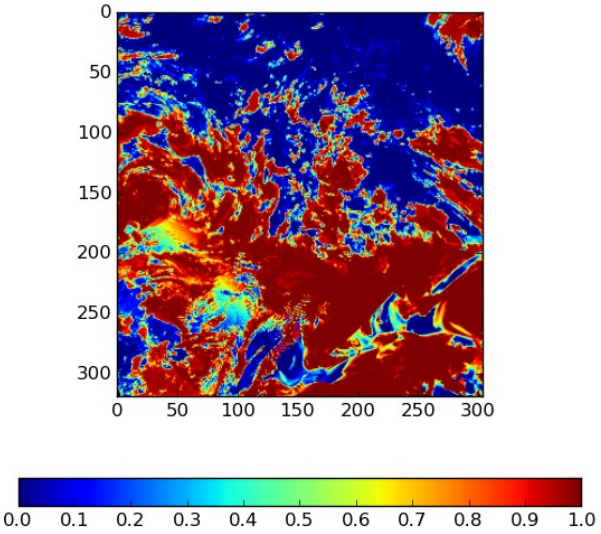


D = B + R

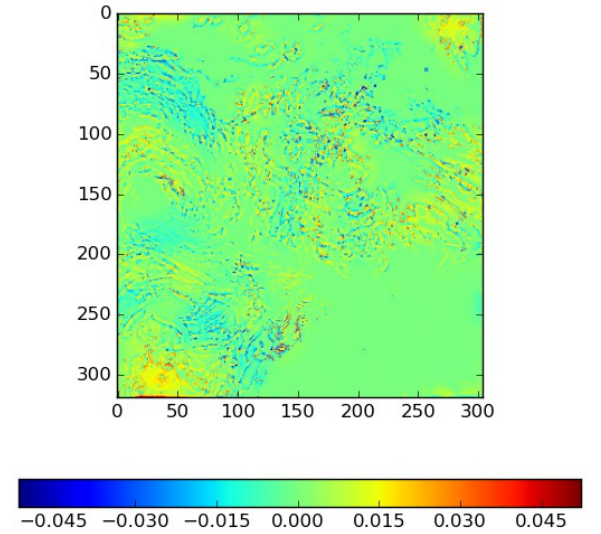
2009 09 01 00UTC



Analysis

$$K_\nu = B_\nu (B_\nu + R_\nu)^{-1}$$

$$X^a{}_\nu = X^b{}_\nu + K_\nu (y_\nu - X^b{}_\nu)$$



Analysis is performed in Fourier space:

+ computationally efficient scheme

- homogeneous observation error covariance

Impact of the re-tuned statistics

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2009 07 01 20 UTC

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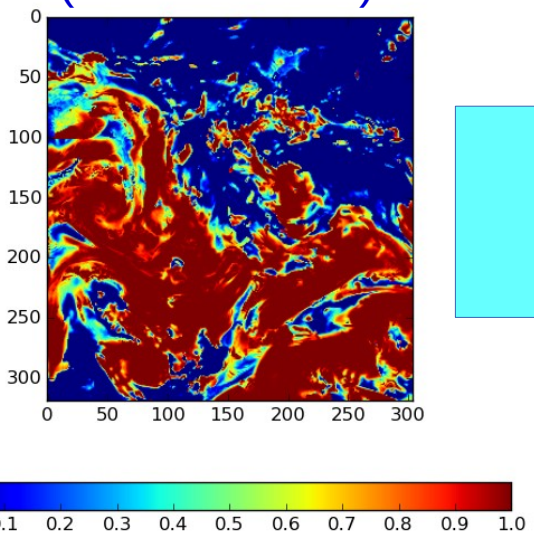
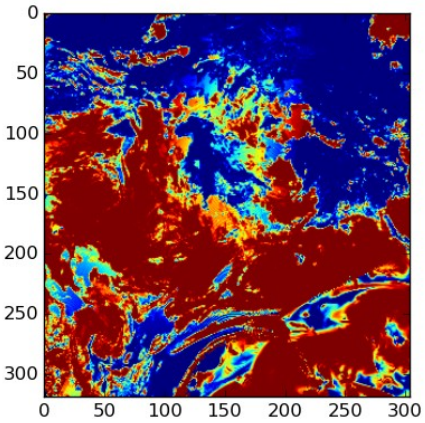
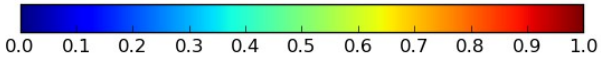
Forecast
(cloud fraction)



MESAN

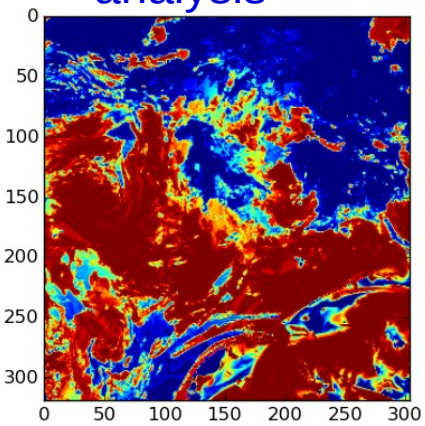
"super"-obs

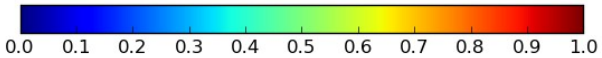




HIRLAM EURO4M
20090701_18+003

analysis





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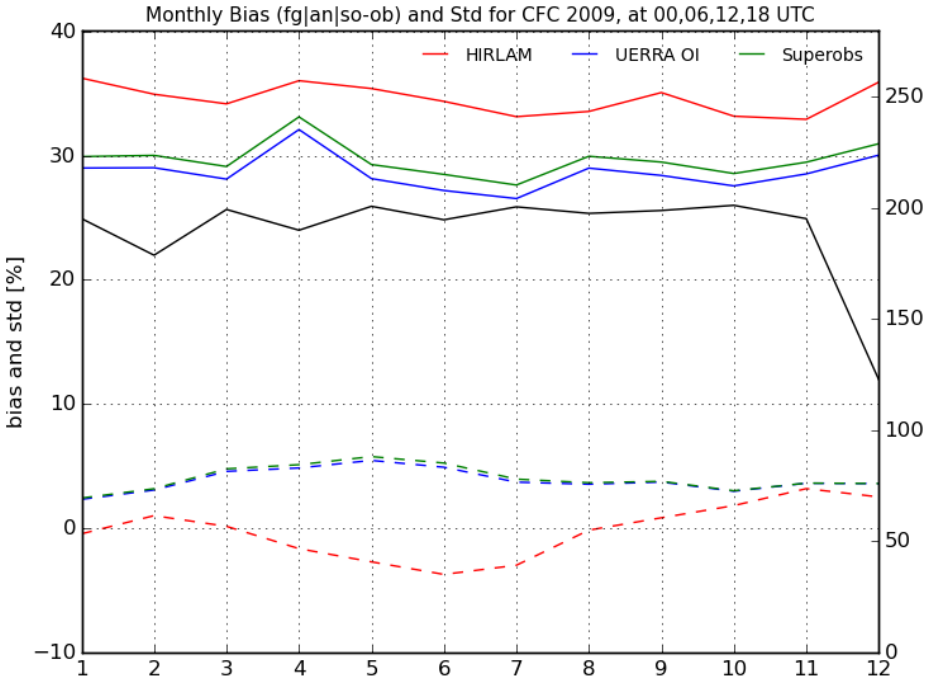
Comparison with SYNOP obs for 2009

+ Analysis has lower std than both the first-guess and super-observations.
- Too much clouds the analysis compared SYNOP.

=>

– investigate impact neighborhood size cobstructing super-observations

– revisit interpretation of cloud cover in SAF products (partial cloudiness?)



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Super-observations: a "gap-filler" problem

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$$y = (\ldots, y_{so}, \ldots, y_{so}, x_b, \ldots, x_b, \ldots.) \Rightarrow \quad A \quad A^c$$

$$\min_{dx} J(dx) = dx^T B^{-1} dx + (y - x_b - dx)^T R^{-1} (y - x_b - dx) \Rightarrow$$

artificial constraints !

$$\min_{dx} J(dx) = \sum_{i \in A} dx^T B^{-1} dx + (y_{so} - x_{bi} - dx_i)^T R^{-1} (y_{so} - x_{bi} - dx_i) + \sum_{j \in A^c} (-dx_j)^T R^{-1} (-dx_j)$$

$$\min_{dx} J(dx) = dx^T B^{-1} dx + (y - x_b - dx)^T w^T R^{-1} w (y - x_b - dx) \Rightarrow$$

$$\min_{dx} J(dx) = \sum_{i \in A} dx^T B^{-1} dx + (y_{so} - x_{bi} - dx_i)^T R^{-1} (y_{so} - x_{bi} - dx_i) + \sum_{j \in A^c} (-dx_j) w_j^T R^{-1} w_j (-dx_j)$$

very small weight

Non-homogeneous problem =>

– Not possible to apply an efficient solution in spectral space

– Alternative approaches are under investigation

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Status and Progress

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Ready

– Extracting GAC orbit data from ECFS
– 1:st estimates of B and R based on NMC statistics
– Re-tuning of B and R statistics based on Desroziers diagnostics
– Super observations (GAC+CLAAS) and OI analysis on 22 km grid

Ongoing

– Reduce wrap around effect of Fourier/DCT transform
– Investigate impact of “gap-filer” on the analysis solution => Does some filtering of the analysis solution is necessary
– Investigate impact of the neighborhood size constructing super-observations
– Revisit interpretation of the CM SAF cloud cover products

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Future plans

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To be done

– Integrate new CMSAF cloud cover probability product (ready 2016, MeteoSwiss) into SO
– Interpolate HIRLAM EURO4M 22 km to 5.5 km with LSM
– Super observations and OI analysis on 5.5 grid
– Validation – look at CMSAF publications

Longer term perspective

(external resources, synergy with HIRLAM-C Program)

– Replace OI analysis with 2DEnVar system for assimilation of cloud cover observations (based on 2DEnVar framework for surface data assimilation)
– Scale-dependent localization in the ensemble framework

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